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ABSTRACT

Researchers investigated the optimum length of teacher inservice activities where increasing teacher efficacy was the goal. Participants were elementary science teachers from seven teacher enhancement projects conducted from 1992-99. The length breakdown of each program was: 1992--6 weeks; 1994--6 weeks; 1995--4 weeks; 1996--4 weeks; 1997--4 weeks; 1998--3 weeks; and 1999--2 weeks. In each of the projects, teachers completed the Science Teaching Efficacy Belief Instrument (STEBI) on the first and last days of the inservice workshops. The STEBI examined personal science teaching efficacy (PSTE) and science teaching outcome expectancy. Data analysis indicated that there was no statistically significant difference between the mean PSTE gain scores on the three contrast variables among the four groups of teachers whose PSTE pretest scores were greater than or equal to 50. This may be due to the fact that teachers already scored high on the PSTE scale. Among teachers whose pretest PSTE scores were less than 50, there were significant gains when comparing the mean gain scores from teachers in the 2- and 3-week sessions and teachers in the 4- and 6-week sessions. It was found that inservice intervention programs had the greatest impact on the efficacy of those teachers who began the program with the lowest efficacy. Given the consistent relationships demonstrated between teacher efficacy and positive student outcomes, inservices impacting teachers' low efficacy are worth close examination. (Contains 32 references and 8 tables.) (SM)

Running Head: CHANGE IN EFFICACY

An examination of change in teacher self-efficacy beliefs in science education based on the duration of inservice activities

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Abstract

Utilizing the data collected from the National Science Foundation, National Institute of Health, and Eisenhower funded teacher enhancement projects, this paper also will present results on the effectiveness of differing lengths of inservice activities in raising teachers' self-efficacy.

An examination of change in teacher self-efficacy beliefs in science education based on the duration of inservice activities

Albert Bandura (1977a, 1997) presented self-efficacy as a mechanism of behavioral change and self-regulation in his social cognitive theory. An efficacy belief is one's perceived ability to carry out actions that will lead successfully toward a specific goal. Bandura proposed that efficacy beliefs were powerful predictors of behavior since they were ultimately self-referent in nature and directed toward specific tasks. The predictive power of efficacy beliefs has been borne out in the research (Bandura, 1997; Pajares, 1996; Tschannen-Moran, Woolfolk, Hoy, & Hoy, 1998).

The recognition and measurement of self-efficacy is especially important to researchers of the social sciences. Bandura (1982) noted that highly efficacious people tend to show higher levels of effort and are resilient in continuing this effort, even in the face of adverse situations. As a result, recognizing and increasing a person's self-efficacy could eventually lead them to work harder and in worse conditions than their counterparts with lower self-efficacy.

When Bandura first published his work on efficacy in 1977, he hypothesized for the social psychologist that there were two dimensions from which efficacy springs: self-efficacy and outcome expectancy. Bandura defined self-efficacy as "the conviction that one can successfully execute the behavior required to produce the outcomes" (1977b, p. 79), and outcome expectancy as "a person's estimate that a given behavior will lead to certain outcomes" (1977b, p. 79).

Many researchers have applied Bandura's social cognitive theory concepts to teachers. Among the first of the researchers were Ashton and Webb (1982). Ashton and Webb argued that two items previously used by RAND researchers (Armor et al., 1976; Berman, McLaughlin, Bass, Pauly, & Zellman, 1977) to study teacher efficacy actually corresponded to Bandura's self-efficacy and outcome expectancy dimensions of social cognitive theory. These two dimensions have subsequently been identified as personal teaching efficacy and general (or outcome) teaching efficacy, respectively. In generalizing these two educational constructs, Schriver and Czerniak (1999) said that "self-efficacy has generally been defined as the belief that one's teaching ability is related to positive changes in students' behaviors and achievement levels, and outcome expectancy is the belief that any teacher, in spite of all other factors, can affect student learning" (p. 23). To further the study of teacher efficacy, Gibson and Dembo (1984) developed the Teacher Efficacy Scale (TES) to measure both of these constructs. The TES was the first attempt to develop an empirical data collection instrument to tap into this potentially powerful variable in teachers.

Teacher efficacy is a context and even subject-matter specific construct. A teacher may feel very confident in his or her ability to impact student learning while teaching mathematics, but quite inefficacious while teaching social studies. Accordingly, some researchers have modified the TES and developed subject matter-specific instruments. Riggs and Enochs (1990), for example, have developed the Science Teaching Efficacy Belief Instrument, or STEBI, and the Microcomputer Utilization in Teaching Efficacy Beliefs Instrument, or MUTEBI (Enochs, Riggs, & Ellis, 1993). Based on the TES, the STEBI and MUTEBI also consist of two dimensions, called personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE), which are believed to correspond with Bandura's self-efficacy and outcome expectancy constructs.

PSTE scores have been positively related to teaching performance (Riggs et al., 1994), teachers' reported enjoyment of science-related activities, and teachers' ratings of the personal relevance of science (Watters & Ginns, 1995). Riggs and Jesunathadas (1993) found that teachers high in PSTE were more likely to spend the time needed to develop a science concept in class. Teachers scoring low in PSTE were reported as spending less time teaching science, rated weak by observers, and less likely to choose to teach science (Riggs, 1995). Teachers' scoring low on the STEBI STOE scale were rated as less effective in science teaching (Enochs, Scharmann, & Riggs, 1995). These teachers often used more text-based, rather than activity-based, instruction and employed less cooperative learning (Riggs, 1995).

Although many efforts have been made to increase the level of teachers' efficacy, and many studies have monitored change in efficacy during the course of an inservice or other training program, little research has been done to monitor the optimum length of these programs with respect to raising teacher efficacy. The purpose of the present paper is to provide a framework for understanding the optimum length of teacher inservice activities when increasing teacher efficacy is a goal of the intervention.

Data collection

More than 330 teachers were involved in the collection of data process. These teachers were drawn from a cohort gathered through seven National Science Foundation (NSF), National Institute of Health, and Eisenhower funded teacher enhancement projects. Inservice programs were conducted in years 92 through 99. The length breakdown of each program is as follows: 1992 – 6 weeks; 1994 – 6 weeks; 1995 – 4 weeks; 1996 – 4 weeks; 1997 – 4 weeks; 1998 – 3 weeks; and 1999 – 2 weeks. In each of these inservice projects, the STEBI was given in a pretest/posttest fashion on the first and last day of the workshops. It is understood that the differing functions and effectiveness of the inservice activities will have higher loadings on change in personal efficacy scores. However, this study has the advantage of analyzing data on the STEBI from a number of inservice programs conducted by the same principal investigators.

One point of concern, also noted by Ross (1994), is the difficulty in bringing about changes in personal teacher efficacy through a staff development program. He and Little (1984) addressed this problem by involving teachers in a more interactive inservice that included teacher practice. The present study used a similar approach. While the length of each inservice differed (between two and six weeks), the purpose and content of each remained the same: to develop inquiry-based science skill and content knowledge among existing elementary teachers through hands on experiences and interaction with experienced master teachers and scientists.

The groups of teachers also were relatively homogeneous, although the number of years of teaching experience differed. All participants in the summer training programs were elementary school science teachers in the Houston area. Although researchers are relatively certain that teaching experience ranged from 1 to 25 years, more specific information was not available for some of the cohorts because of the archival aspect of some of the datasets. As a result, only STEBI scores and lengths of interventions could be used in this analysis. The uncertain consistency and availability of other types of demographic data made it impossible to include those factors in the analysis at this time.

The Outcome Expectancy Scale of the STEBI

Once data from the seven different measurement occasions were collected, reliability estimates were conducted to confirm the data used for analysis in this report. (The correlation matrix for the data analyzed in this paper is presented in Table 1.) The first step was to perform a confirmatory factor analysis (CFA) using the items from the STEBI to model a two-factor solution (PSTE and STOE). This analysis was performed with AMOS 4.0.

Results obtained demonstrated the model fit to the data was not very strong. Table 2 illustrates the findings from the CFA. The fit statistics from the CFA seem to indicate that there are some problems with either the data or the model design.

Insert Tables 1 and 2 about here

When these problems were noted, an exploratory factor analysis was performed to determine if the items actually were being allowed to load on the right factors. When the exploratory two-factor solution was run with the data, all items were placed in the factors that Riggs and Enochs (1990) had originally defined. Although the two-factor solution confirmed the loadings of the items into the two originally hypothesized factors, it was noted that this solution only accounted for 38.5% of the variance. While the two-factor solution is very parsimonious, it brings to question the reliability of a solution that cannot explain more than 60% of the overall variance. However, even the seven-factor solution explains only 60% of the variance. Stevens (1996) states that, as a general rule of thumb, someone would want the factors extracted to account for at least 70% of the variance.

The question that arises is whether or not the instrument produces reliable data and if that data is appropriate to use for the purposes of monitoring teacher efficacy. Further analyses performed on the STEBI data showed that most of the items that loaded on the first factor (in the two-factor solution) continued to load on that factor when a four and five-factor solution was designated. The items defining that first factor make up the personal science teaching efficacy (PSTE) scale of the STEBI.

Insert Tables 3 and 4 about here

Other researchers also have noted the problems associated with the outcome expectancy scale (STOE) of the STEBI. In particular, Tschannen-Moran et al. (1998) have argued that this dimension is a measure of external locus of control, as opposed to outcome expectancy. Several researchers support this conclusion (Guskey & Passaro, 1994; Coladarci & Fink, 1995). Given that the STOE scale of the STEBI was modeled after the TES, then the STOE scale also likely evaluates external locus of control. With the possible exception of the article by Schriver and Czerniak (1999), few research projects have noted differences in the outcome expectancy dimension of the STEBI (c.f. Cannon & Scharmann, 1994). For this reason, only the PSTE scale of the STEBI was used when performing analyses for this paper.

Data analysis

When first exploring the data, it seemed there was a relatively small difference between the cohorts in the four different lengths of inservice programs (2, 3, 4, and 6 weeks). Upon closer examination, however, it seemed that there was a ceiling effect among the people who scored high on the PSTE scale of the STEBI pretest. As a result, efforts were made to identify teachers who scored low on the PSTE scale pretest and a criterion was set that teachers scoring below the mode score (50) were separated from the rest of the dataset to be used in further analyses. These teachers were chosen not only because of their low score, but also because they had more potential for improvement than their counterparts. The data in Table 5 appear to validate this decision.

Insert Table 5 about here

Another concern of the analysis was the use of gain scores. Although Huck and McLean (1975) suggest using an ANCOVA type design over the use of gain scores, they do provide estimations of gain score reliability for when a gain score method is needed instead of ANCOVA designs. By obtaining the average reliability between the pre and posttest and the correlation between the two tests, one is able to determine the gain score reliability. The computation stems from the fact that "as the correlation between pre and posttest scores approaches the reliability of the test, the reliability of the difference scores goes to 0" (Stevens, 1996, p. 328). Using Huck and McLean's estimation procedure, we were able to determine that the gain score reliability is .67 based on an average reliability (alpha) of .7717 and a correlation of .372.

After results from data in Table 5 had been consulted, it was decided that a planned contrast design should be used instead omnibus hypothesis testing because of the relative strength of interpretation of results when compared with omnibus hypothesis testing (Hinkle, Wiersma, & Jurs, 1998). The contrasts tested in the ANOVA are listed in Table 6. These contrast variables were then used in a regression equation (the planned contrast ANOVA) to predict the gain scores in the PSTE scale among the teachers scoring below 50 on the pretest.

Insert Table 6 about here

Analyses also were conducted with data obtained from the teachers who scored above 50 on the PSTE scale of the STEBI pretest. The same contrasts were used when examining the differences between the scores of the different lengths of inservice experiences among this group.

Results

The purpose of this analysis was largely experimental. Based on the data available, researchers were interested in the optimum length for an inservice activity that had as a target increasing teacher self-efficacy. The first area of interest involved the increase in efficacy of teachers who originally scored below 50 on the PSTE scale pretest of the STEBI. When these data were analyzed with a planned contrast analysis, it was noted that differences between mean PSTE gain scores among teachers in the 2-week and 3-week programs and differences between mean PSTE gain scores among teachers in the 4-week and 6-week inservice programs were not statistically significant. However, when the mean PSTE gain scores of the teachers in the 2-and 3-week programs were contrasted against the mean PSTE gain scores of the teachers in the 4-and 6-week programs, statistically significant results were found, thus rejecting the null hypotheses that the mean gain scores of these two groups were the same. Results from this first analysis can be found in Table 7.

Insert Tables 7 and 8 about here

The same contrasts then were carried out with the gain scores from teachers whose score was greater than or equal to 50 on the PSTE scale of the STEBI pretest. This analysis produced no statistically significant results among the teachers' mean PSTE gain scores in the first contrast (2-week and 3-week vs. 4-week and 6-week), the second contrast (2-week vs. 3-week), and the third contrast (4 week vs. 6-week). Therefore, we failed to reject the null hypothesis that there was no difference in teachers' mean PSTE gain scores for the three contrast variables.

Discussion

The first discovery of note, which came at no surprise, was that there was no statistically significant difference between the mean PSTE gain scores on the three contrast variables among the four groups of teachers whose score on the PSTE scale pretest was greater than or equal to 50. This outcome might be interpreted as a result of the fact that teachers already scored high on the PSTE scale. Therefore, there was not a lot of room for improvement or mean PSTE gain score increase. These results would be expected from any study where a ceiling effect occurred. They also seem to correspond with the current literature showing the difficulty in raising the self-efficacy of teachers who already have high levels of personal self-efficacy or who are experienced teachers (cf. Anderson, Greene, Loewen, 1988; Ohmart, 1992). Since self-efficacy is formed at least partially from one's experiences, as teachers move into their career, their efficacy beliefs tend to become less malleable.

The second outcome, which probably is of more practical importance, is the result from the analysis involving teachers whose score on the PSTE scale pretest was less than 50. This group provided the most room fc growth in self-efficacy, and is exactly the group that many teacher inservices target for improvement. From Table 7, we can extrapolate that statistically, in terms of mean gain scores on the PSTE scale, there is no difference between a 2-week and a 3-week training session, nor is there a statistical difference between a 4-week and 6-week session. The benefit in this area is largely in terms of cost. Suppose an administrator were faced with the decision of sending his/her teachers to either a 2 or 3-week inservice program. All other factors being equal (e.g., quality of presentation and amount of material covered), the results of this study show that teachers' efficacy will be raised about the same in either program. If one of the goals of sending teachers to the inservice were to raise their self-efficacy, and if cost were not an issue, then the administrator would be able to save money and send the teachers to the 2-week program, rather than the 3-week program. Likewise, in terms of self-efficacy, administrators would do just as well to send their teachers to a 4-week inservice, rathe- than a 6-week inservice (all other things being equal).

There was, however, a statistically significant difference on the PSTE scale when comparing the mean gain scores from teachers in the 2-and 3-week sessions and teachers in the 4-and 6-week sessions. The results from this contrast variable in Table 7 have interesting consequences. For the administrator or program designer, they tend to suggest that a 4-week inservice is probably the best use of resources if the goal of the program is to raise teachers' self-efficacy and money is not an issue.

Conclusion

While the results from the first contrast variable in Table 7 are statistically significant, it should be noted that this contrast only has an R^2 of .038 and an adjusted R^2 of .033. Although Cohen would categorize this effect size as small, it still seems to be resilient when accounting for sampling error, as reflected in the lack of shrinkage in the adjusted R^2. Because the effect size is small, researchers are cautioned from interpreting results as pillars for how long an inservice should be. In fact, this small effect size demonstrates the need for further research in this area. Future research should include not only teachers in the primary grades, but also in the secondary grades, and should include other measures of teacher expertise, such as teaching experience and previous training.

Despite the small effect size, this paper can begin the process of providing information about the relative cost-effectiveness of inservice programs designed to increase the self-efficacy of teacher participants. The results of the present study are compelling because the inservice interventions had the greatest impact on the efficacy of those teachers who began the program with the lowest efficacy beliefs. Given the consistent relationships between teacher efficacy and positive student outcomes and teaching behaviors (see e.g., Anderson et al., 1988; Coladarci, 1992; Gibson & Dembo, 1984; Moore & Esselman, 1992; Podell & Soodak, 1993; Soodak & Podell, 1993), inservices that can impact the low efficacy in individual teachers are worth close examination.

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Table 1

STEBI data correlation matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00														
2	.233	1.00													
3	.104	.333	1.00												
4	.371	.206	.072	1.00											
5	.162	.381	.357	.168	1.00										
6	.069	.162	.492	.101	.324	1.00									
7	.147	.064	-.058	.232	-.070	-.082	1.00								
8	.127	.389	.567	.083	.344	.391	-.125	1.00							
9	.296	.176	.033	.331	.098	-.006	.372	.020	1.00						
10	.104	.016	.132	.158	-.018	.024	.303	.001	.179	1.00					
11	.400	.159	.089	.357	.041	.050	.241	.125	.372	.131	1.00				
12	.173	.312	.335	.109	.402	.272	-.051	.387	.114	.108	.164	1.00			
13	.064	.138	.190	.180	.118	.119	.223	.122	.213	.259	.084	.076	1.00		
14	.263	.104	.014	.214	.064	.033	.234	.046	.304	.168	.342	.098	.077	1.00	
15	.332	.097	.052	.361	.044	.054	.304	.040	.328	.297	.407	.140	.235	.506	1.00
16	.313	.165	.135	.335	.143	.054	.237	.150	.402	.075	.451	.059	.193	.452	.362
17	.162	.255	.407	.017	.393	.394	-.074	.385	.120	-.056	.097	.369	.138	.060	.089
18	.180	.318	.251	.148	.358	.305	.000	.274	.198	-.016	.190	.409	.080	.092	.108
19	.096	.230	.424	.055	.401	.235	-.092	.418	.037	.088	.023	.367	.149	-.027	-.019
20	.107	.150	.149	.078	.068	.198	.178	.206	.209	.197	.141	.076	.282	.167	.162
21	.169	.386	.466	.089	.322	.341	-.040	.465	.109	.120	.077	.388	.093	.131	.190
22	.112	.309	.453	.085	.414	.339	-.034	.424	.124	-.054	.095	.429	.095	.083	.052
23	.175	.453	.370	.162	.316	.259	.039	.351	.218	.006	.134	.338	.155	.186	.141
24	.168	.437	.480	.103	.452	.355	-.039	.472	.204	.028	.052	.356	.177	.121	.110
25	.100	.141	.158	.086	.089	.149	.181	.074	.262	.273	.205	.002	.273	.195	.256

	16	17	18	19	20	21	22	23	24	25
16	1.00									
17	.111	1.00								
18	.123	.457	1.00							
19	.082	.484	.294	1.00						
20	.167	.122	.046	.139	1.00					
21	.183	.364	.304	.369	.090	1.00				
22	.103	.550	.461	.458	.110	.516	1.00			
23	.178	.399	.414	.336	.159	.401	.516	1.00		
24	.185	.467	.348	.477	.159	.494	.569	.472	1.00	
25	.162	.124	.051	.097	.219	.141	.124	.190	.220	1.00

Note: N=331

Table 2

Results from the CFA of the STEBI data

Fit Measure	Value
Chi Square	625.749
CFI	.855
PCFI	.781
NFI	.771
GFI	.863
RMSEA	.062
AGFI	.838

Table 3

2-factor solution pattern matrix and structure matrix of STEBI data

	Pattern Matrix		Structure Matrix	
	Factor 1	Factor 2	Factor 1	Factor 2
1		.514		.539
2	.522		.558	
3	.708		.700	
4		.569		.575
5	.640		.636	
6	.579		.566	
7		.609		.556
8	.710		.697	
9		.664		.666
10		.433		.418
11		.656		.654
12	.605		.612	
13		.360		.388
14		.634		.626
15		.725		.713
16		.641		.652
17	.710		.700	
18	.570		.587	
19	.675		.651	
20		.324		.356
21	.662		.674	
22	.770		.759	
23	.615		.648	
24	.744		.755	
25		.405		.428

Note: Extraction method: Principal Component Analysis
Rotation method: Promax with Kaiser Normalization

Table 4

Total variance explained by factors from the STEBI data

Factor	Eigenvalue	% of Variance	Cumulative %
1	6.290	25.160	25.160
2	3.342	13.368	38.528
3	1.553	6.212	44.740
4	1.067	4.268	49.008
5	1.006	4.024	53.032
6	0.980	3.918	56.950
7	0.922	3.688	60.638

Table 5

Descriptive statistics for the PSTE scale of the STEBI data

Model	Mean	Median	Mode
STEBI pretest	46.95	48	50
STEBI posttest	53.53	53	53
Gain scores	6.58	6	3
Gain scores by length of intervention			
2 weeks	5.04	5	6
3 weeks	6.24	5	5
4 weeks	7.47	8	3
6 weeks	6.47	6	1
Gain scores by pretest scores			
Pretest < 50			
2 weeks	7.47	7	7
3 weeks	8.65	6	5
4 weeks	10.32	11	7
6 weeks	10.16	10	10
Pretest >= 50			
2 weeks	2.32	3	4
3 weeks	4.20	5	5
4 weeks	2.21	2	0
6 weeks	3.54	4	1

Table 6

Contrasts for regression of STEBI data for teachers scoring below 50 on the PSTE scale of the pretest.

Session	Test for the difference between 2 week and 3 week session	Test for the difference between 4 week and 6 week session	Test for the difference between 2 week and 3 week vs. 4 week and 6 week session
2 week session (n=45)	1.00	0.00	2.00
3 week session (n=17)	-2.65	0.00	2.00
4 week session (n=107)	0.00	1.00	-1.00
6 week session (n=19)	0.00	-5.63	-1.00

Table 7

Planned Contrast ANOVA for the PSTE scale of the STEBI data for teachers scoring below 50 on the pretest.

Model	SS	df	MS	F	Sig	R^2
2 & 3 weeks vs. 4 & 6 weeks	260.399	1	260.399	7.375	.007	.038 (.033)*
2 weeks vs. 3 weeks	17.192	1	17.192	0.487	.492	.003 (-.003)*
4 weeks vs. 6 weeks	0.412	1	0.412	0.012	.915	.000 (-.005)*
(Subtotal)	*278.004*	*3*	*92.668*	*2.625*	*.052*	*.041 (.025)**
Error	6496.805	184	35.309			
Total	6774.809	187				

Note: * Adjusted R^2 in parenthesis

Table 8

Planned Contrast ANOVA for the PSTE scale of the STEBI data for teachers whose scores were greater than or equal to 50 on the pretest.

Model	SS	df	MS	F	Sig	R^2
2 & 3 weeks vs. 4 & 6 weeks	4.304	1	4.304	.148	.701	.001 (-.006)*
2 weeks vs. 3 weeks	49.175	1	49.175	1.711	.193	.012 (.005)*
4 weeks vs. 6 weeks	24.777	1	24.777	.857	.356	.006 (-.001)*
(Subtotal)	*81.423*	*3*	*27.141*	*.938*	*.424*	*.020 (-.001)**
Error	3991.451	138	28.924			
Total	4072.873	141				

Note: * Adjusted R^2 in parenthesis